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THE AMERICAN METEOROLOGICAL JOURNAL.

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THE AMERICAN

METEOROLOGICAL JOURNAL.

VOL. IX. BOSTON, MASS., DECEMBER, 1892. No. 8.

ATMOSPHERIC ELECTRICITY, EARTH CURRENTS, AND TERRESTRIAL MAGNETISM.

PROF. CLEVELAND ABBE.

WHILE we hope that the progress of knowledge will soon give us some clear view and rational theory of the nature and origin of the electrical phenomena of our atmosphere and earth, yet it must be confessed that at present only a few special students of the subject seem to feel that our knowledge and our theories justify some degree of hopefulness as to the future of this branch of science.

The following letters from the electricians of the Western Union Telegraph Company and of the Commercial Cable Company and from the secretary of the International Ocean Telegraph Company have been kindly contributed by them to this JOURNAL and should excite the attention of meteorologists; these records illustrate the magnitude of the great electric disturbances that frequently occur on our planet. The future must decide to what extent these phenomena are of importance in climatology and meteorology, but every one now recognizes that there can be no question as to their practical importance relative to all magnetic phenomena and to all those whose business depends upon the use of the compass needle. Swift ocean steamers whose compasses are checked hourly by observations of sun and stars, when possible, must often, during cloud and fog, run for many hours by the compass alone, and will, therefore, be many miles out of their courses if a magnetic storm happen to deflect the compass needle several degrees, as occurred on July 16. Magnetic storms affect the needle as cyclonic storms affect the winds; and as the needs of sailing vessels have

demanded the study of meteorology and winds, so the needs of "the ocean grayhounds" and the steel cruisers now demand the study of magnetism and earth currents.

If I am not mistaken, the interests of telegraphy will also be advanced by a better understanding of earth currents. The general rule of progress has been that science, so called, promotes and is often the main stay of practice; it is patent to all, that the practical applications of our knowledge of electricity will increase in importance in proportion as the means are provided for further study of the laws relating to that branch of physics. Our universities and schools of science are daily seeking not merely to instruct young engineers in all that is known, but to increase the sum total of our knowledge. Those who help these fountains of learning are insuring the steady progress of civilization. The conquest of nature and the development of man are synonyms.

The inter-relations of earth-currents, auroras, terrestrial magnetism and atmospheric electricity are so complex that we are but slowly arriving at a solution of the question as to which is the cause and which is the effect. At present Prof. Bigelow's researches are, I think, confirmatory of the hypothesis that all these are the several consequences of the rapid translation of the rotating earth through the field of electric force that emanates from the sun. While I leave the detailed study of these cosmic relations to my colleague, I may, however, take the liberty of indicating that in my opinion the various electrical and magnetic observatories that have hitherto been established, observing as they do respectively only some part of the whole series of phenomena, need to be supplemented by completely equipped establishments that shall keep continuous records of the three components of each form of electric phenomena, *i. e.*, the N-S, the E-W and the zenithal-antipodal differences of potential. We need to know the local potential gradients in atmospheric electricity, magnetic force, and earth current. The determination of the vertical earth-current-gradient requires a vertical insulated wire of considerable length; and to this end there can be utilized the great dry well of the Wheeling Improvement Company, which is already becoming famous in scientific literature through the labors of Prof. Dr. Wm. Hallock of Columbia College.

The ordinary records of atmospheric electricity give us merely the difference of potential of the earth and a point in the atmosphere defined as the end of the water dropping collector; but the connection between the electric condition of the atmosphere and earth would be best elucidated by having three such collectors located at points respectively north and east and above a central collector so that we get the difference, or gradient, of potential in each of the three co-ordinate directions.

For want of such a complete system of electric investigation we are at present only able to draw some very general inferences from the following valuable letters of Messrs. Finn and Cuttriss and Clark. We have here recorded, on July 16, large differences of potential on grounded overhead wires between New York and Boston, Providence, Elizabeth, and Philadelphia, as also between Chicago and Omaha, and in general on east and west lines. Presumably the records are all in eastern time (five hours earlier than Greenwich time). The maximum gradients were about three volts per mile between New York and Providence at 12 29 P. M.; two volts per mile, New York and Boston, at 12.40 P. M.; fifteen volts per mile, New York and Elizabeth; 1.6 volts per mile, New York and Philadelphia; one volt per mile, Chicago and Omaha. But these gradients are only "apparent gradients," and labor under the same difficulty as explained by Mr. Cuttriss in reference to the ocean cable; the gradient may, and very probably does, vary at every point of the telegraph line. If the disturbance has a local origin then this origin would be best ascertained by observing on each short section of the long lines. In general, however, the observed differences of potential (or the potential gradients per mile or per degree of a great circle), are such as would be due to the rapid arrival at any point of very various currents travelling along the telegraph wire; and are such as would be produced by the passage of our globe with its system of superficial telegraph wire conductors through a region of space in which local differences of potential temporarily exist. The rapid passage of our earth through these irregular electric fields produces the so-called ground currents on grounded wires, or induced differences of potential in insulated wires. If we knew the vertical as well as we do the horizontal components of these earth currents, we might more accurately determine the location in space

of the normals to these wave surfaces; as it is, we can only say that the direction in space of the motion of the earth's centre on July 16 must have been approximately perpendicular to the earth's radius vector. The direction of motion of New York city and the wires centring there would, of course, be very nearly parallel to this, or towards ecliptic longitude 23°, and the diurnal rotation would not greatly change this direction from hour to hour. The fact that the maximum disturbances on the telegraph lines came an hour or less after noon is not to be attributed necessarily to electric waves that come from some other direction than that of the sun, but as Prof. Bigelow has shown, may be a phenomenon of retardation or lag, similar to that observed in revolving copper discs, and depending on the relative velocity of the earth and the waves in the free æther of space as compared with their velocity in the less free æther (gebunden or weighted æther) of the earth.

CAMBRIDGE, Aug. 15, 1892.

[Since the above was written the electrical journals have published further details of the next great disturbance of August 12, and some have hazarded the conjecture that we have really had three or four successive recurrences of electric storms coincident with the rotation of some special portion of the sun's surface or possibly of a solar spot. There is, however, as yet, nothing published to demonstrate that this twenty-seven day period is really a solar rotation period; from a physical point of view it is equally possible that this periodicity arises from a monthly conjunction of the sun and moon producing periodical tidal strains within the earth's crust and a development of piezo-electrical currents, an idea that was first published by Clerk Maxwell in Vol. II., Article 474, of his "Electricity and Magnetism."

WASHINGTON, Sept. 18, 1892.]

(I.) LETTER FROM MR. WILLIAM FINN.

The following article was written by Mr. William Finn of the General Operating Department of the Western Union Telegraph Company at 195 Broadway, New York, and is presented to the American Meteorological Journal with his compliments by W. J. Dealy, manager W. U. T. Co., New York, July 23, 18 2.

THE ELECTRIC STORM OF JULY 16, 1892.

The unprecedented magnitude, duration, and extent of the electric storm of July 16, 1892, will undoubtedly make that event a memorable one in the history of electrical phenomena. There had been indications of its approach both on aerial and submarine lines for some hours prior to the actual outbreak which occurred at 12.20 P. M. The first noteworthy reading was obtained on a grounded wire between New York and Boston at 10.10 A. M., at which time the current strength measured 5.3 milliamperes. At 12.20 A. M. the current had increased to 14 milliamperes and was very variable in polarity. It continued to vary both in magnitude and direction until 10.40 A. M., when it attained a value of 28 milliamperes. Five minutes later it fell to 2 milliamperes and was comparatively steady, but jumped up to 35 milliamperes (representing a potential difference of 101.5 volts for a few moments) at 10.50 A. M., and commenced to rapidly fluctuate again.

A few minutes later the force began to gradually subside, and at 11.07 A. M. it had dropped to zero. The wire was then cut and grounded at Providence and the following readings obtained on it: —

Time.	Current Strength.	E. M. F. Developed.
12.05 P. M.	9 Milliamperes	20.7 Volts.
12.07 "	42 "	113.4 "
12.12 "	43 "	11.6 "
12.15 "	.8 "	2.1 "

— with intermediate values between those periods: no fewer than one hundred and fifty reversals in the direction of the current were noted between 12.05 P. M. and 12.10 P. M. At 12.20 P. M. the current suddenly rose to 68.5 milliamperes, and at 12.29 P. M. had acquired the tremendous value of 280 milliamperes under a pressure of 644 volts. This was the maximum point reached and probably represents the highest electromotive-force ever obtained in connection with earth current manifestations.

The above observations were made and all readings taken on a tangent galvanometer provided with suitable shunts.

The following current values were taken from a milliam-meter inserted in a New York-Boston wire measuring about 3700 ohms: —

Time.	Current Strength.	E. M. F. Developed.
12.37	27 Milliamperes.	99.9
12.39	32 "	118.4
12.39½	48 "	177.6
12.40	44 "	162.8

Time.	Current Strength.	E. M. F. Developed.
12.40¼	133 Milliamperes.	492.1
12.41	68 "	251.6
12.43	20 "	74.0
12.44	15 "	55.5
12.45	19 "	70.3
12.46	14 "	51.8

A wire between New York and Elizabeth, N. J., showed the following variations: —

Time.	Current Strength.
1.51 P. M.	55 Milliamperes.
1.53 "	15 "
1.55 "	80 "
1.55½ "	95 "
1.56 "	25 "
2 "	40 "
2.10 upwards of	150 "

The maximum difference of potential between the distant grounds being about 210 volts.

Other wires of different lengths and extending in various directions showed equally strong and fluctuating forces traversing them, notably in a New York-Philadelphia wire, and in a circuit between Chicago and Omaha, in which pressures of 140 and 390 volts respectively were obtained.

The line of least intensity at any time during the disturbance was apparently north and south, though circuits running in this direction were frequently as useless for practical purposes as those in the direct line of the storm.

The exciting forces quieted down somewhat by 3 P. M., but continued to interrupt the wires (more especially those running east and west) at short intervals during the remainder of the evening.

They were active at irregular intervals and for variable periods all night, and during a portion of the following day.

They have not since been observed on aerial lines, but appear to have subjected the Atlantic Cable Circuits to further inconvenience on Monday and Tuesday, July 18 and 19.

(2.) LETTER FROM MR. CHARLES CUTTRISS.

The Commercial Cable Company. Mackay-Bennett Cables.
New York, July 23, 1892.

Prof. Cleveland Abbe.

Dear Sir, — Yours referring to the electrical phenomena of the 15th, 16th and 17th to hand.

I take pleasure in giving you all the data we have on hand,

but as you will understand, our receiving apparatus is of the most delicate order and we never permit any strong currents to pass through it. Consequently of the major part of the disturbances we have no record. Further, in order to prevent our business being delayed by extraneous currents, we employ condensers in circuit with our apparatus, and therefore currents of considerable intensity could exist on our cables without our having any record of them unless they varied somewhat rapidly in potential, when of course they would manifest themselves. This will undoubtedly account for our not observing any disturbance during the 15th or 17th, and on the 16th only for a period of about two and one-half hours. The electrical waves attained sufficient strength and changed in potential with sufficient rapidity to record themselves at 12.21 P. M. on the 16th inst. They were quite strong, and in some cases between 12.21 and 12.25 the difference of potential must have exceeded 50 volts. Between 12.25 and 12.28 I judge there were cases of upwards of 50 volts difference of potential from 12.28 to 12.30. I do not think any wave gave a difference of more than 30 volts. From 12.30 to 12.31 one wave possibly gave a difference of 50 to 60 volts. From 12.31 to 12.39 no wave exceeding 15 to 20 volts. From 12.39 to 12.39.45 there were 6 waves of about 35 to 45 volts, but from 12.39.45 to 12.40, there was a wave of such exceptional severity that in order to save our instruments I at once put the cable to earth. This wave undoubtedly must have exceeded 100 volts. From this time until 2.56 P. M. we occasionally found periods when work could be safely resumed, but from 2.56 P. M. we have no further disturbance recorded. I regret my inability to furnish you with more exact data, but you will understand that from the reasons given above we cannot take the risk of damaging our instruments or the cable by attempting to measure these currents, but on the first approach of a severe disturbance we ground the whole apparatus. The differences of potential that I have given are such as I should judge would cause a wave of the character recorded, if it was applied in the form of a battery at the distant end of the cable, but as you will understand it does not necessarily follow that both ends of the cable were of opposite sign, and the current recorded may have been transferred through the dielectric; in this case both ends of the cable would have the same sign, and the disturbance producing it must have been enormously larger than the figures I have quoted.

If at any time I can be of service to you in connection with these or other observations, I should be most happy to do all in my power. Yours truly,

CHAS. CUTTRIS,
Electrician C. Cable Co.,
Room 116, *Drexel Building, New York.*

To PROFESSOR CLEVELAND ABBE.

(3.) LETTER FROM MR. THOMAS F. CLARK.

EXECUTIVE OFFICE.
INTERNATIONAL OCEAN TELEGRAPH COMPANY.
NO. 195 BROADWAY, NEW YORK, Aug. 24, 1892.

CLEVELAND ABBE, Esq.,
Associate Editor, "American Meteorological Journal:"

Dear Sir,— Your esteemed favor of July 20, asking me for a statement of the effect of the electrical storms upon the cables of this company in July, was duly received, and I referred it to our cable manager at Key West for report. His absence from home has delayed his reply. I now, however, beg to send you the following extracts from the diaries of our offices at Punta Rassa, Fla., Key West, Fla., and Havana, Cuba, which I trust will be of service:—

"PUNTA RASSA, July 16.

"12.30 P. M. both cable circuits opened south for three minutes, then Key West and Havana signals reached here very unsteady, quick changes from strong to light currents; impossible to work the duplex circuit. Changed to single circuit, but signals very unsteady and at times circuit completely open. This lasted all the afternoon and evening, interfering greatly with exchange of signals."

"KEY WEST, July 16.

"2.15 to 2.30 P. M. could not work duplex circuit owing to strong earth currents coming and going at quick intervals. Also experienced great difficulty in working the circuit single. This lasted all the afternoon and evening. At times could only work the circuit by shutting off our regular battery current and utilizing the earth currents."

"HAVANA, CUBA.

"Reports same effects noticed there, and that the Cuba Sub-Marine Company's cables between Havana and Santiago de Cuba were so seriously influenced that all traffic was suspended. NOTE.— This latter company uses the 'mirror flash' instruments, which are more easily influenced by irregular earth currents than the Morse system (as used by us) would be. Therefore, it is highly probable that the unusual currents experienced south of Havana were not more severe than what was felt between Havana, Key West, and Punta Rassa. I am unable to say whether the currents experienced were positive or negative, coming out of the cables, but from what I can learn from the operators judge THAT REVERSALS were frequent. There was nothing unusual experienced on the fifteenth or seventeenth."

Yours truly,

THOS. F. CLARK, *Secretary.*

NOTES ON THE USE OF AUTOMATIC RAIN GAUGES.

JOHN E. CODMAN.

DURING the last quarter of a century the value of a systematic and correctly made series of meteorological observations has been fully appreciated by all professional men, whether interested in scientific research or in engineering projects. Especially so is it with those, who, in the pursuit of their engineering profession have been called upon to investigate present and future sources of water supply for our growing cities and towns. Scattered local records of this character have been kept by individual effort, and when they can be collated and tabulated in a systematic manner, furnish valuable statistics for reference. It is only within the last score of years that any effort to systematically collect accurate meteorological data has been made. The result shows that in many instances portions of former data were to a large extent estimates and approximations ; especially so was this in regard to rainfall data. Automatic rain gauges showing the amount and rate of precipitation have been used only within a few years past. Observations made by the writer upon a self-registering gauge during the past five years, revealed some discrepancies that at first seemed unaccountable without some means of comparison. The diameter of the collector of the automatic gauge was twenty-two and five-eighths inches. It was intimated that correct results could not be obtained from collectors of so great a diameter. To definitely settle this point of size, collectors from two to eight inches in diameter were obtained and placed, at the same elevation, in close proximity to the large one, so that the condition relating to locality should affect all alike.

Observations upon these have been made continuously for the past three years. The results show that with an average yearly rainfall of forty-five inches the variation between the smallest and largest is less than three quarters of one per cent, and also show that it makes no practical difference whether the collector is twenty-four inches in diameter or only two inches. During

1888 it was found that the automatic gauge on the roof of the small building did not collect as much as one placed upon or near the surface of the ground. During 1889–1890 and 1891 observations were made with a collector twenty inches from the ground. The results showed that about thirteen per cent more was collected in the ground gauge. In order to determine whether this discrepancy was due to the difference in elevation above the surface of the ground or was caused by local conditions, a series of collectors were suspended upon a mast at elevations of fifty feet, twenty-five feet, fifteen feet, ten feet, and five feet above the surface of the ground. Small lead pipes leading from each collector conveyed the water to separate vessels. The drawing of the mast and collectors in elevation shows the relative position of the collectors on the mast, and the drawing in plan shows their relative position to the points of the compass. During the year observations have been made at the end of each rain storm, noting the general direction of the wind and the amount of rain collected.

The results tabulated in the table are compared with those obtained from the gauge on the ground and the automatic gauge. There is no material variation in the amount for each month or for the year between the gauges on the mast and the one on the ground, yet the variation in single storms will at times amount to as much as three tenths of an inch, according to the direction and velocity of the wind. This variation it was soon found was caused by the mast producing counter currents of air. Although the mast was only eight inches in diameter, and the collectors ten inches in diameter, and suspended at a distance of five feet from it, yet those on the windward side collected more than those on the lee side. The wind in the majority of storms had an easterly direction, and the gauges on the northeast and southeast sides of the mast collected the greater quantity. Comparing the results obtained, it is found that a gauge at an elevation of fifty feet or less above the surface of the ground will collect the same amount as one on the ground, provided both are situated in a position not affected by counter currents of air.

The thirteen per cent difference observed between the automatic gauge. the gauges on the mast and the gauge on the ground was to be traced to some other cause.

*TABLE SHOWING OBSERVATIONS ON RAINFALL AT DIFFERENT ELEVATIONS ABOVE THE SURFACE OF THE GROUND.—1891.

Month.	Elevation above surface of ground.						Number of Observations.	Direction of Wind.				Automatic Gauges.		
	0	5	10	15	25	50		N. E.	S. E.	S. W.	N. W.	Flat Roof.	Gable Roof.	
													F. H. N.	F.
April	2.44	2.34	2.22	2.26	2.34	2.32	6	3	1	1	1	2.21	1.65	1.97
May	1.86	1.57	1.67	1.82	1.72	1.73	10	5	1	2	2	1.59	2.32	1.90
June	2.95	3.02	2.78	2.99	2.90	2.84	8	7	1	–	–	2.79	3.56	2.36
July	5.88	5.28	5.71	5.75	5.70	5.53	10	3	4	2	1	5.45	4.15	7.30
August	4.99	4.63	4.92	4.88	4.96	4.78	11	1	3	3	4	4.68	4.64	7.75
September	2.65	2.64	2.73	2.70	2.68	2.65	6	2	1	1	2	2.46	2.94	1.97
October	3.05	2.98	3.18	3.37	3.54	3.24	5	4	–	1	–	2.88	3.26	3.08
November	2.38	2.14	2.46	1.98	2.30	2.20	5	2	1	2	–	1.72	1.65	1.49
December	4.32	4.47	4.74	4.21	4.56	4.50	7	2	3	1	1	3.87	4.13	4.44
1892.														
January	4.44	3.71	3.62	3.57	3.62	3.54	9	5	1	1	2	3.81	4.64	4.22
February	1.04	0.87	1.06	0.99	0.94	1.14	8	5	1	2	–	0.84	0.86	0.45
March	5.06	4.45	4.47	4.14	4.34	3.96	11	9	–	–	2	4.29	4.63	4.27
Total	41.06	38.10	39.56	38.66	39.60	38.43	96	48	17	16	15	36.59	38.43	41.20
Percentage from April, 1891, to April, 1892												89%	93%	94%
Total of ground gauges from April, 1891, to April, 1892												41.06	41 31	43.88
Percentage averages of four years, January to January												13	11	11

*Began making observations April 1, 1891.

The automatic gauge in Philadelphia is placed upon the roof of a small office building with a slight inclination. The automatic gauges at Spring Mount and The Forks of the Neshaning are placed upon the roof of a small building constructed for the purpose with a sharp gable roof. The two views show these buildings, the relative position of the collectors and the pitch of the roofs in each.* Observations with a ground gauge are made at all these stations and compared with the automatic. The results for the year 1891 are given in the table headed "Automatic Gauges, Flat Roof, Gable Roof." The total for the year by the automatic gauge flat roof is eighty-eight per cent of the amount collected upon the ground. The total amounts for the year collected by the Automatic Gauges Gable Roof are ninety-three and ninety-four per cent respectively of the amount collected on the ground. All the collectors as will be seen on inspecting the pictures are not affected by surrounding objects producing counter currents of air.

This leads to the conclusion that the discrepancy in the amounts collected by the Automatic Gauges is due to the roof of the building on which they are placed. The shape, size, and inclination of the roof giving a different result in each case. It seems that currents of air striking against the surface of the roof below the gauge move upward and carry a portion of the rain over the collector. Any gauge or collector placed upon an elevated structure, so that a surface beneath will cause upward currents of air, will be subject to this defect.

Nearly all automatic rain gauges are subject to this error, and it will vary according to the position of the collector above the roof.

It might be possible to raise the collector high enough to be above the ascending currents, but in most cases it would be inconvenient and impracticable to do this. A better course seems to be to find a correction in percentage for each particular case. The automatic gauge is not reliable for ascertaining the equivalent value of snow, especially if the storm is attended by high winds. The writer has used, for this purpose, for a number of years, a piece of two (2) inch brass tube about forty

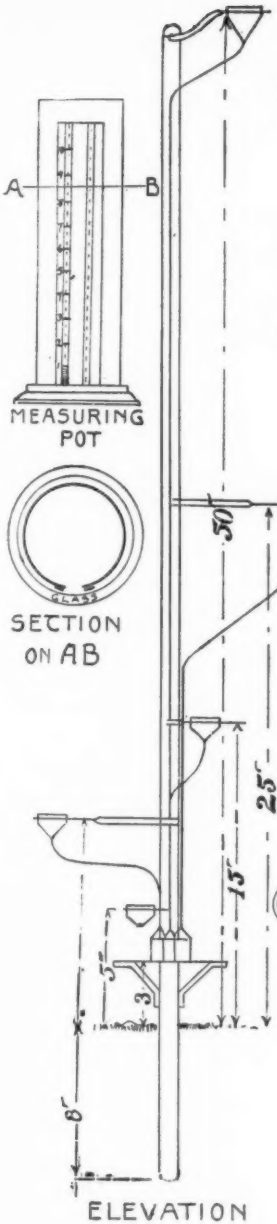
* In drawing the view showing the mast, the latter has been placed close to the building, in order to make the plate smaller. In reality the mast is at some distance from any building.

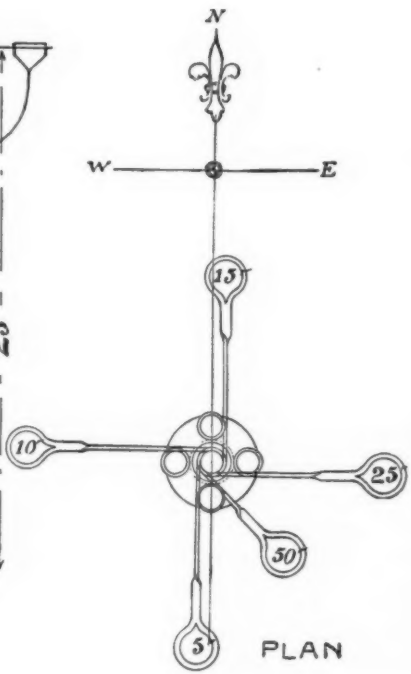
RAIN GUAGES

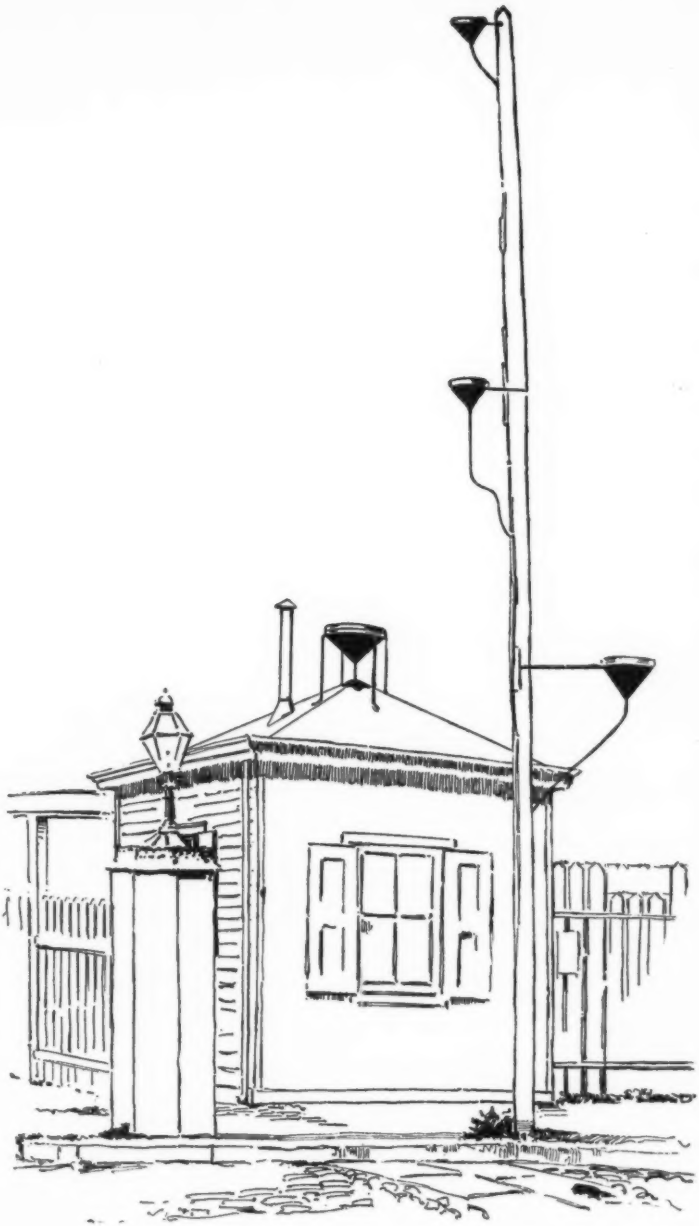
FOR

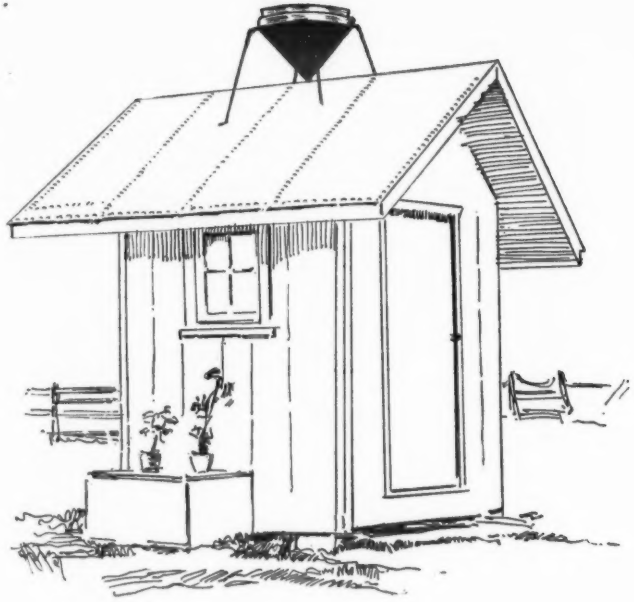
OBSERVING AMOUNT OF RAIN
AT
DIFFERENT ELEVATIONS
ABOVE SURFACE OF GROUND

1891









inches long, open at top and closed at the bottom. This is placed in an upright position in any suitable place as soon as the snow begins to fall. The long tube, no matter how high the wind may be, traps the snow flakes, and it is afterward melted into water and recorded as so much rain. Automatic rain gauges give us beyond all doubt the very best records attainable, but judgment and care must be exercised in their use that the records may be relied upon.

Theories have been advanced and curves plotted to show that as the distance from the ground increased the less rainfall.

All of these theories might perhaps be traced to the same errors that were found in the above notes.

SUNSHINE RECORDERS.

PROF. C. F. MARVIN.

THUS far two methods only have been used by meteorologists, in general, for the registration of sunshine. The one takes advantage of the intense heat of the sun's rays when brought to a focus and, by means of a lens, scorches or burns out, on a card, a record of the time and duration of what may be called bright sunshine. The second method operates by the aid of photography to produce a trace of the time and duration of sunshine on suitably sensitized paper. This latter method, in general, is susceptible of a greater degree of sensitiveness than the burning process, and is able to record fainter sunshine. About twenty stations of the weather bureau have been using this type of recorder; and the particular pattern adopted, regarded simply as a photographic instrument, has proved to be very satisfactory. The successful action of the sensitized paper is very uncertain and seems to depend upon various atmospheric conditions, especially moisture. The best results are obtained from cool and dry stations or during sunshiny months. Cloudy skies and humid atmospheres seem to lead to rapid deterioration of the prepared paper, and the same paper at different stations gives widely different results.

The Weather Bureau pattern of this instrument is shown in

Fig. (1). The main cylinder, forming a closed, dark case for the record sheets, is mounted upon the support, as shown, and can be set at various angles of inclinations according to the latitude of the place. The cylinder is also detachable without disturbing its adjustment for latitude, and can be removed to a darkened room for examining or exchanging sheets, etc.

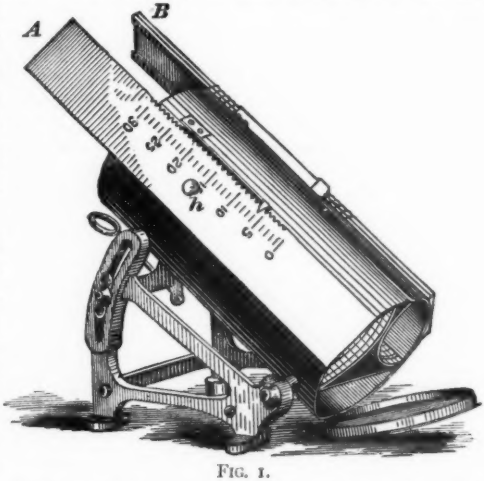


FIG. 1.

The sides of the cylinder are slotted for several inches and covered with notched slides which are clearly seen in the drawing. Each of these slides is pierced with a very small and very flatly bevelled hole, the one being presented more or less directly towards the forenoon and the other towards the afternoon sun. Within the cylinder are arranged two segments of cylinders, the axes of which coincide respectively with the central lines of the two slots, each to each. The sensitized blue print paper used in the record sheets is fitted to conform to the concave surfaces of these segments, the lower end of one of which, with a portion of the rulings on the sheet, is seen in the figure.

As mentioned above, the slides are notched and, to secure the record for consecutive days of the month, are to be set in a new notch each night. During sunshine the small holes in the slides act to produce very minute images of the sun at some particular spot on the paper; and this image, by the apparent motion of the sun, traces a more or less continuous line from nearly sunrise to noon and from noon to nearly sunset. In order to bring the successive months' record at the same place on the sheets and thus facilitate identifying the successive days of any month, notwithstanding the changes in the sun's declina-

tion, the record sheets have a system of twelve lines ruled across the bottom end, one line for each month. The positions of the lines and the intervals between have relation to the positions and movement of the sun in declination for the corresponding months. The sheets for any particular month are cut off on the proper monthly line and when placed in the instrument the sun's image comes within, practically, the same prescribed limits for each month.

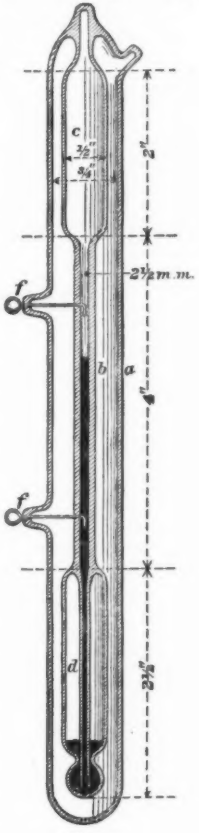


FIG. 2.

It is difficult to secure uniformity in the blue print paper for these instruments, and often the same paper in different localities, presenting different atmospheric conditions, will give widely different results. The instrument is not regarded as very satisfactory. These circumstances led to the development of the new form of electrical sunshine recorder shown in Fig. (2). Mr. D. T. Maring of the Weather Bureau was the first to advance in this direction, and suggested a form of bimetallic differential thermometer which, however, on trial, proved to lack sensitiveness and was too sluggish. The idea was developed by the writer in the form shown in Fig. (2). It consists in principle of a Leslie differential air thermometer. Mercury, however, is used to separate the air in the two bulbs, and the whole thermometer is designed in the form of a straight tube having a bulb at each end, as shown in the cut. The lower bulb is uniformly coated with lampblack. This arrangement, when the tube is placed approximately parallel to the earth's axis, affords similar exposure for the two bulbs during the entire period of sunshine. It further admits of enclosing the thermometer within an outer glass tube for protection from weather. The interspace is carefully exhausted. The construction by which the air is separated in the two bulbs is clearly seen in the drawing. Two platinum electrodes are fused into the stem as seen.

After thoroughly drying the inside of the bulbs and stem by well-known processes, pure dry air is admitted, and the whole brought to a low temperature so as to secure a greater density of air than otherwise. The outlet at the top of the instrument is then fused and the air exhausted from the outer sheath.

It is not difficult, after the instrument is filled, to adjust the quantities of air in the two bulbs, so that when the instrument is inclined with its axis nearly parallel to that of the earth, that is, at an angle of nearly forty degrees in these latitudes, the mercurial column will rise to within a short distance of the upper platinum electrode, the bulbs being at the same temperature. When so adjusted and exposed to sunshine, the lower blackened bulb becomes heated, causing the column to rise above the platinum point and close an electric circuit. To secure uniformity in a large number of instruments, the angle of inclination to the vertical, at which any particular instrument should be set in order to agree with a standard, can be determined by proper comparisons and the instrument always set accordingly.

Very satisfactory results have thus far been obtained though only the crudest devices, such as we have been able to make ourselves, have been tested. The instrument is capable of considerable delicacy of adjustment and responds to sunshine and shadow quite promptly.

The register for this device may be made in a great variety of forms. For example, the opening and closing of the circuit may be made to stop and start a clock, which for convenience might be set each evening with its hands at twelve. Now, since the clock runs only while the instrument indicates sunshine, it is plain that the position of the hands at any time during the day marks the number of hours and minutes of sunshine up to that time. A more complete record is obtained by the use of a register precisely similar to the ordinary Gibbon's anemometer register, long used in this service. The recording pen or pencil tracing its line upon the revolving sheet of paper is drawn aside when the circuit is closed, thus marking the time of beginning of sunshine, and returns to its normal line whenever there is cloudiness or at the end of sunshine. The most desirable method of registration, however, and the one altogether followed in the trials of the instrument thus far, is a modification of the latter method. Instead of allow-

ing the circuit to remain closed the entire time of sunshine and thus use up a great deal of battery material, the circuit is passed through contact arrangements in the clock movement used to drive the recording cylinder. These contacts are automatically closed for a few seconds by the clock once each minute, or, in some cases, once each five minutes. If at this time the circuit is also complete through the instrument the current flows, the pen of the register makes a short lateral mark and soon returns to its normal position. By these means that portion of the record marking sunshine consists of a line having short lateral strokes at regular intervals of either one minute or five minutes, as the case may be. The record during cloudiness or night time is an unbroken line.

Unfortunately, this thermometric recorder is not susceptible of transportation without great danger of derangement. After being once adjusted, it must not be inclined very far from a vertical position.

The means adopted for electrical registration by the fixed platinum contact does not admit of recording relative intensity of sunshine. This, however, may be observed by reading the position of the mercurial column in the stem, which should be graduated into some sort of scale for that purpose. The electrical registration of the position of this column may even be worked out in the future.

WASHINGTON, Oct. 13, 1892.

LATE INVESTIGATION OF THUNDERSTORMS IN WISCONSIN.*

WILLIS L. MOORE.

WITH ninety reporters well distributed throughout Wisconsin considerable data has been secured during June, July, and August, 1892, study of which has been made to determine,—

First. Direction and rate of progressive movement, and the relation of same to upper and lower air currents.

Second. Average length of storm track, and feasibility of giving warning of the approach of local storms a few hours in advance.

* Reprinted from the Wisconsin "Weather and Crop Journal."

Third. Is electricity the initial force, or only an energizing influence after the storm formation?

Fourth. Anticyclonic movement of winds for brief period during passage of storm.

It is clearly shown by the June storms that 75 per cent move toward the east; and of these easterly-moving storms 50 per cent move northeast, 27 per cent east and 23 per cent southeast. In other words, as many go to the northeast as to the east and southeast combined. This agrees with the general northeasterly tread of the tornadoes.

Thunderstorms have their origin in an upper stratum of air and are rapidly propagated towards the earth's surface. Taking their initial direction from the well-known easterly movement of the upper current they might be expected to move due east if acted on by no other force. But the storm cloud extends downward nearly to the earth's surface, and its lower extremity is brought in contact with the usual southerly winds prevailing during conditions favorable to thunderstorm development. A cursory examination of data would conduce to the belief that the prevailing northeasterly direction is the resultant of these two forces, and that the angle of inclination to the true east would be proportioned to the exact direction and velocity of the southerly winds.

Let us see how the facts bear out this assumption. On the 6th of June the surface winds were fresh from the southeast, and of 61 thunderstorms 29 moved toward the northeast, 14 northwest, 8 east, 6 north, 2 west, 1 southeast, 1 southwest, and none south: nearly as many moving northeast as to all other directions combined. On June 16, the winds were from the northeast, and of the 29 thunderstorms, instead of the greater number moving toward the southeast, a plurality moved northeast, the same as when the surface winds were nearly from the opposite direction.

Evidently the surface movement of air exerts but little influence on the storm direction, and some other cause must be looked for. Probably the easterly-moving upper current, when in the vicinity of a cyclonic area and on its eastern side, partakes somewhat of the revolving motion of the general storm area, and is temporarily deflected toward the northeast. But little information is at hand respecting the velocity with which

these storms travel, but the rate is probably thirty to fifty miles per hour.

The general easterly direction being established, we next consider the time necessary for a thunder cloud to exchange and neutralize its electrical energy, and the distance that the storm will travel before this is accomplished, assuming that it will be dissipated when the neutralization of its electrical force has been accomplished. On the length of storm track and rate of progression depend, in great measure, the practicability of giving warning of the approach of any particular storm. If it be shown that this track is not more than ten or twenty miles in length and the movement at the rate of thirty miles per hour, the difficulty in reaching the agricultural and other interests lying in its track will be apparent. In a given territory — say the State of Wisconsin — do thunderstorms first develop on its western border and move eastward across the State, with such temporary variations in course as might be caused by the contour of the earth's surface, running water, woodland or lakes, preserving their identity throughout the 200 miles' course? Or, are they spontaneously developed throughout the whole stratum of air covering the State — in the east as well as west — and are numerous thunderstorms precipitated at nearly the same moment, by a want of electrical energy, none of which travel more than ten or fifteen miles, and many less?

In but few cases can an affirmative answer be given to the first, while to the latter question the reverse is generally true. On August 8, sixteen storms occurred, fourteen of which occurred in the early morning, about the time of minimum temperature. Low pressure over State. Here is a clear type of the regular progression of a heavy thunderstorm, with uniform velocity throughout an extended track, so often noted in more eastern States. It began in St. Croix County, on extreme western border of State, at 1.40 A. M., travelled eastward at the rate of forty-seven miles per hour, and reached Manitowoc County, on the eastern border of State, a distance of 236 miles, at 7 A. M. It was nine times observed in regular succession across the State, and each moment of arrival was in proper cadence to establish the eastward velocity of forty-seven miles per hour. The precipitation was rather heavy for this latitude, and very evenly distributed, and about the same time was required to

pass each observer. Its breadth of track was from five to ten miles. This storm, pursuing its course at about the hour of minimum temperature, found a very equable distribution of vapor and temperature and a constant electrical condition. Hence its route of progression, precipitation, and duration, at each point of observation, were nearly uniform. Had the hour of day been anywhere near the time of maximum heat, when the varying constitution of different surfaces have their unequal heat-radiating properties magnified by a high temperature, the result would have been different — probably numerous light showers, of very limited area, tracks five to ten miles in length, and no systematic connection.

Charts have been prepared showing for each date the exact moment that each storm began and the direction in which it was moving at the different points from which reports are received. In but very few cases does a storm reported at one place reach reporting stations directly in its course and only fifteen, twenty, or twenty-five miles distant; and seldom has it been possible to trace a storm across the State. Twice during July were thunderstorms observed at La Crosse, moving north, but with five reporting stations lying in their track, at intervals of ten miles; neither of these storms were cited at other stations. At Red Wing four storms were observed moving into Wisconsin, none of which reached any of our reporting stations, although they could not have travelled fifty miles without encountering several. A storm reported at Princeton, moving northeast, could not have moved twenty miles without being observed by several attentive reporters; none but the first observer saw it. Storms at Columbia, moving east, could not have travelled ten miles without being observed several times; none but first observer saw it. Numerous similar cases might be cited, showing that while the thunderstorm stratum covered the State, storms were numerous, of very limited area and abbreviated track, and many would prevail in the eastern and western part of the State at the same time. To illustrate the difficulty of successfully giving warning of the approach of these storms, let us suppose a storm to appear at La Crosse, at 1 P. M., moving east. A telegram is at once sent to Milwaukee which is delivered not earlier than 2 P. M., and the Milwaukee official sends telegrams to the towns lying fifty or one hundred miles

east of La Crosse notifying them that a thunderstorm may be expected during the afternoon. But the storm expends its energy after travelling ten or fifteen miles, and has probably ceased to exist before the La Crosse message reaches Milwaukee. Too much time is taken in the sending of these telegrams. But suppose the observer who first notes a storm, no matter whether he be a regular or voluntary observer, telephone or telegraph to the nearest town or point lying in the track of the storm, with which communication can be had; and if the storm reach this place, the second observer in turn notify the next place, and so on. I believe this to be the only practical method of giving thunderstorm warnings. The rapid extension of the telephone system will, in a short time, render this perfectly feasible. The main obstacle would be to secure prompt and efficient attention without compensation. If a competent official be authorized to visit the different towns and villages, he could doubtless induce the municipal authorities to direct some of their employees to attend to this work, and also to pay for messages where arrangements could not be made for free service. At rural railway stations the station agent or postmaster might be secured.

So far, this season, the thunderstorm condition has been easily recognized on the morning map; and with slight exception the morning forecasts have predicted rain, showers, or thunderstorms whenever they have occurred during the following twenty-four hours; this has, of course, obviated the necessity of sending out special warnings. But the exact path that each storm will pursue is what the farmer wishes to know. If the plan should meet with the approval of the Chief of the Bureau, it is intended next spring to attempt the organization of an interdependent thunderstorm warning system for the whole State; the idea being to have each town or small farming settlement assume the responsibility of notifying the town nearest it and in line of the storm whenever a storm passes its own burg, and in turn to receive the same from its neighbors; some official or employee to be properly authorized to receive and disseminate the information, and to at once hoist a local rain flag. Each storm would then keep its messengers in the van heralding its coming until its force was expended. Such information would be nearly as reliable and much similar to the block system of signalling railway trains, where they announce their own ap-

proach several minutes in advance. Under the present system numerous storms have occurred on many days when the telegraphic warning stations on the west of Wisconsin failed to report to the forecast official at Milwaukee the passage of thunderstorms, and he was in total ignorance of the movements of each storm. Again on several days when storms were reported by telegraph from the warning stations in the west, they failed to enter the State to a distance greater than five or ten miles; and had special forecasts been sent out based on these western reports, they would have failed of verification. At other times, when telegraphic reports were received from the western stations, subsequent mail reports showed that storms were in progress at many places in the State several hours before being observed at these telegraphic stations.

The present system of gathering data by supplying voluntary observers with cards has worked well, and it is believed that the first step has been taken towards a better understanding of this hitherto neglected branch of meteorology.

It is believed that a careful study of the data gathered in relation to these storms will result in a material modification of the theory that lightning is only the effect of high or unequal temperature distribution and gathering vapor, or at most, only an energizing force in the storms. Several types of thunderstorm conditions are shown where electricity seems to be the initial force, where the electrical tension seems to have reached such a strain that there was almost synchronous development of numerous thunderstorms throughout a vast stratum of air, much like the instantaneous lighting throughout a great expanse of territory of many electric lights by a single current. There seems to be no such thing as the development of a few storms in the western part of the storm condition, and their regular movement eastward through its whole area. To be sure, nearly every storm takes up an easterly course, but as soon as there has been a thorough exchange between like and unlike electricity through the medium of its vaporous clouds, and a consequent neutralization of electrical energy, and the re-establishment of its equilibrium, the storm ceases after travelling but a few miles.

The downward and outward flow of cold air from the upper stratum during the passage of a thunderstorm directly over the

observer was perfectly illustrated at Milwaukee on Aug. 5, 1892. The storm occurred just before the morning observation, causing the barometer to suddenly rise one tenth of an inch, so that the reading appeared to be erroneous when compared with Chicago, Grand Haven, and La Crosse. The temperature fell about three degrees. Had the hour been near the time of mid-day heat, the change of temperature would doubtless have been ten to twenty degrees. The barometer settled back as soon as the storm had passed. The same fluctuations in pressure were observed with the passage of thunderstorms directly over station on July 24 and 28, but in a less degree.

But little time has been available for the study of this interesting subject, and many vulnerable points will doubtless be discovered in my deductions. I hope to profit much from the reports of others who have been working on these lines.

OBSERVATIONS ON THE AURORA OF JULY 16, AT UTICA, N. Y.

T. W. HARRIS.

THE year 1892, especially its first half, will be remembered among meteorologists for the great number and brilliancy of its auroral displays. One of the most remarkable of these was that which occurred on the evening of July 16, and which the writer had the good fortune to observe at Utica, N. Y. His attention was first called to it at about nine o'clock; and, ascending to the roof, from which an unobstructed view of the sky could be obtained, he watched the spectacle for somewhat over two hours.

When first seen, the aurora consisted of several bright irregular patches of light in different parts of the sky, chiefly in the north and northeast, which varied from time to time in brightness; at times also expanding so as to cover a considerable part of the sky, and again shrinking down to a few small bright spots. The changes in brilliancy took place quite suddenly, the effect being somewhat similar to the changes which might be produced in the illumination of a room by the quick turning up or down of the wick of a lamp.

For some time the aurora continued to present this aspect;

but at about half past nine a pale light appeared near the northern horizon, gradually spreading and brightening, until nearly the entire sky was covered by it. The bright patches, however, still continued visible in the midst of this fainter glow, though they did not retain fixed positions, but shifted from place to place, now one portion of the sky, and now another, appearing bright in turn. The color of the light, which, up to this time had been a clear white, now gradually changed to a pale lemon yellow; at the same time the light assumed a striated appearance, at first faint, but becoming more and more distinct, until the whole sky was covered with long rays, which converged toward a point southeast of the zenith, elevated about seventy degrees above the horizon. About the point to which the rays converged, appeared a large irregular mass of light, of curiously gnarled and twisted aspect.

Up to this time the light had had the character of a steady glow, changing only by becoming at irregular intervals more and less bright. But with the appearance of the rays, or striations, there appeared also a slight quivering in them, at first very faint and very rapid, but becoming gradually more distinct and less rapid, until it assumed the character of waves of light, running in quick succession up from the horizon to the gnarled centre where the rays converged.

The display continued to present this character for nearly an hour, varying, however, in brilliancy from time to time. But at about half past ten, the color of the light, which had hitherto been of a pale yellow or yellowish white, underwent a striking change. Instead of the uniform color which had hitherto prevailed, streaks of varied hue appeared, and the light became now reddish, now of a purple or violet tint, then once more yellowish; while again at times it would assume a curious iridescent aspect, in which the yellow, red, and purple colors were strangely commingled, the changes taking place with great rapidity. These changes of color continued for ten or fifteen minutes, at the end of which the aurora assumed a purplish tint, brightest in the northeast, but becoming less pronounced in other directions. This color slowly faded, however, and gave place once more to the white light. Then the wave-light flashes became less and less distinct, and the striations gradually disappeared, leaving only a uniform glow, which, in its turn became

pale and misty in appearance, and gradually breaking up at length disappeared.

Through all these variations, the gnarled nucleus to which the rays converged underwent the least change of any portion of the aurora, and when the aurora broke up, remained visible, though faint, for a considerable time after the light in its immediate vicinity had faded away.

The writer has seen more brilliant auroras, but never any more remarkable for variety of aspect, beauty of color, or rapidity of change. Apart from a few notes in the local papers, however, it does not seem to have been widely noticed, but it unquestionably deserves to be placed on record as among the most singular and interesting ever seen.

. . . . . .

While speaking of the auroras of the past summer, an obser vation as to an allied phenomenon may not be amiss. During the month of July, the writer was in charge of a party of geological students in central and eastern New York. On Thursday, the twenty-first of July, the class, being in the vicinity of Catskill, had occasion to determine carefully the compass direction of the old "King's Road" at a point about two miles west of the town, for the purpose of correcting the map in use by the members. As we stood in the road, holding our compasses in our hands (the time being a little after nine in the morning), a curious motion of the compass needles was observed, which made the reading of them very difficult. In order to eliminate possible sources of error, the hammers of the party were removed to a safe distance, and the compasses placed level upon the ground in the road. The needles swung to and fro upon their pivots before coming to rest; and it was observed that quite frequently, they would bound back as they swung, before reaching the limits of their arcs of vibration, as if they had encountered some invisible obstacle. It was noticed that the bound was towards the west, and not in the opposite direction; that is, that the sudden and unexpected reversal of the motion of the needles took place when their north poles were swinging toward the east; and though some irregularity of motion was observable at times during the westward half of the swing, the needles did not then bounce back as they did while swinging eastward. The conclusion was strongly suggested of the existence of an intermittent

attracting force from some invisible source to the west of north. The fact of this action being simultaneous on the part of the different compasses would seem to show that its source lay outside of the compasses themselves, and was not due to any internal cause, such as their being placed in an unlevel position. Knowing, furthermore, that the presence of an aurora is commonly attended with more or less disturbance of the magnetic needle, the class was led to infer that the cause of the phenomenon lay in the existence of an aurora, invisible, however, at that time, on account of the bright daylight which then prevailed. The phenomenon continued for some twenty minutes, after which the needles ceased to be affected, and the compasses could again be used in the usual manner.

CAMBRIDGE, MASS.

TEMPERATURE SEQUENCES.

PROF. H. A. HAZEN.

IN the April number appeared an article by Mr. Gawthrop giving the view that there was a certain tendency for long continued spells of heat and cold in our weather, and trying to prove this by observations of temperature at Philadelphia. A few suggestions were made by the present writer in the July number indicating the defects in the argument and in the material worked upon. In the October number Mr. Gawthrop abandons his former position with great alacrity, and now tries to prove that there are continued terms of heat or cold, lasting at least six months, by observations at San Diego. As the original contention is given up, there is really no need of continuing the discussion, but there are one or two points in the later paper that demand a little attention. The author selects years in three groups of consecutive mean monthly values for the six cold months, November to April, and by continuing them in his way he tries to show that the mean of each group of seven years shows a regular progression or, in other words, the mean temperature of each month of the first group is higher than that for the month of the same name in the third group, while the values in the second group lie between these. Given a series of values. with a privilege of picking out and combining in any order he

chooses, would enable one to prove almost anything he desired. In the example before us, out of the forty-two figures in group one that seem to show a prevalence of continued heat, there are twenty-five exceptions, and in each of the other groups there are seventeen exceptions; surely no one would insist on any law where there are so many exceptions. The fact is, in each of the columns there are several high temperatures, and when these are summed they serve to apparently obliterate the exceptions.

The proper way to discuss such a series of observations would be to strike a general mean for each of the six months of the twenty-one years under discussion, and then subtract the figure for each individual month from this mean. By so doing I find that there are only three years that seem to show any law; and one of these cannot be counted for the reason that the temperatures used were taken from the mean of the maximum and minimum and not from the thrice daily observations. These latter range from one to two degrees higher than the others, and this explains the continuous high record in this year. Out of the twenty-four departures, since the maximum and minimum began to be used, there are only seven with a minus sign. I submit that two coincidences out of twenty-one cases can hardly be said to establish a law. But this is not all; the method of exposing the thermometers was changed three times at this station, and it might easily be that with so slight a margin the effect of such changes would be appreciable. Protest should be entered against this attempt to prove a law in meteorology by observations at a single station, especially after a similar attempt at Philadelphia resulted in failure. That there are sometimes heated terms lasting for four or five consecutive months need not be wondered at; in fact, they may be confidently expected, but there is hardly anything more certain than the fact that there is no law in the matter. If any one should predict five consecutive months of temperature above the mean because the November value was above, he would not hit it more than ten or fifteen per cent of the time even at the favored station picked out for this discussion; and at other stations it is very doubtful if he would hit it as often as that.

Oct. 15, 1892

CURRENT NOTES.

THE MAURITIUS HURRICANE OF APRIL 29, 1892.

By the kindness of Mr. Meldrum, we are able to present our readers with the accompanying seven plates, giving fac-similes of the records of the Beckley self-registers at the Royal Alfred Observatory.

As it is not often that continuous registers from the centre of a hurricane are obtained, we have reproduced Mr. Meldrum's diagrams and figures as supplementary to our article on this subject in the September number of this JOURNAL. We regret the unavoidably small scale of our diagrams.

Mr. Meldrum states that "fortunately the observatory suffered very little in the hurricane. We made every possible preparation. While some parts of the island were almost completely wrecked, other parts suffered little." Mr. Meldrum was not personally present at the observatory on the 28th; he left at 3.20 P. M. on the 27th, and returned at 11 A. M. on the 29th. "Before leaving, on the 27th, I sent the following note to our local newspaper: 'Heavy weather to the northward since the 24th'; which, as the barometer had fallen 0.156 inch, and the wind had veered from E. S. E. ½ S. to E. by S., meant that there were indications of a cyclone. But as cyclones often occur to the northward of us in April and May, after the hurricane season in Mauritius is over, no danger was apprehended till the 29th."

The original barograph record, as supplemented by the dotted line where the light failed, seems to show that three moments of barometric minimum occurred, *i. e.*, at the centre of the eye of the storm, and at about the moment when the hurricane lulled, and when it began again. Several hypotheses suggest themselves in explanation of this phenomenon, viz.: —

(*a*) That the storm centre moved in a complex re-entering curve, instead of a simple parabola, and passed over the observatory three times, but this is very improbable; (*b*) That one or two special local whirls, with low centres or special gusts producing low pressures on the right-hand side in the southern hemisphere, passed over the observatory; (*c*) That the winds of the main whirlwind varied in intensity, thus producing, at rather regular intervals, a general rise and fall of pressure in its central region; (*d*) That the violent winds preceding and following the lull produced a special suction and fall of pressure within the barograph room of the observatory. The examination of these and other hypotheses can best be done by special studies at the observatory itself. We think that the third hypothesis is very likely to be true, and to represent a general phenomenon in both hurricanes and tornadoes.

C. A.

PLATE I.

ROYAL ALFRED OBSERVATORY, MAURITIUS.

ANEMOGRAPH CURVE No. 118.

From Wednesday, April 27d 9h 4m to Thursday, April 28d 9h 2m, 1892.

The space travelled over is obtained by multiplying by 3 (Dr. Robinson's original Factor) the distance actually run by the cups.

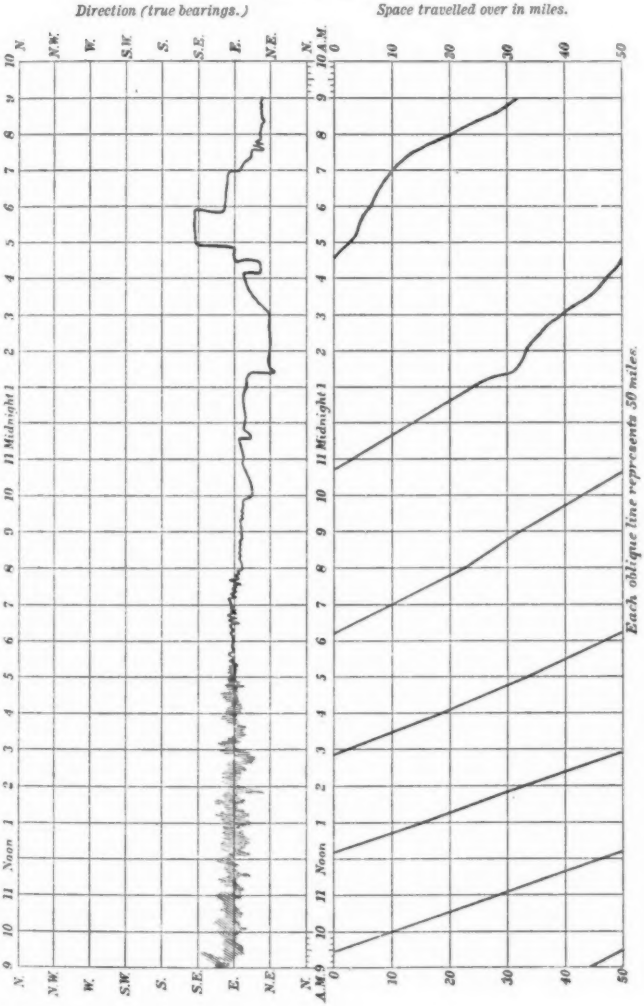


PLATE II.

ROYAL ALFRED OBSERVATORY, MAURITIUS.

ANEMOGRAPH CURVE No. 119.

From Thursday, April 28d 9h 5m to Friday, April 29d 9h 2m, 1892.

The space travelled over is obtained by multiplying by 3 (Dr. Robinson's original Factor) the distance actually run by the cups.

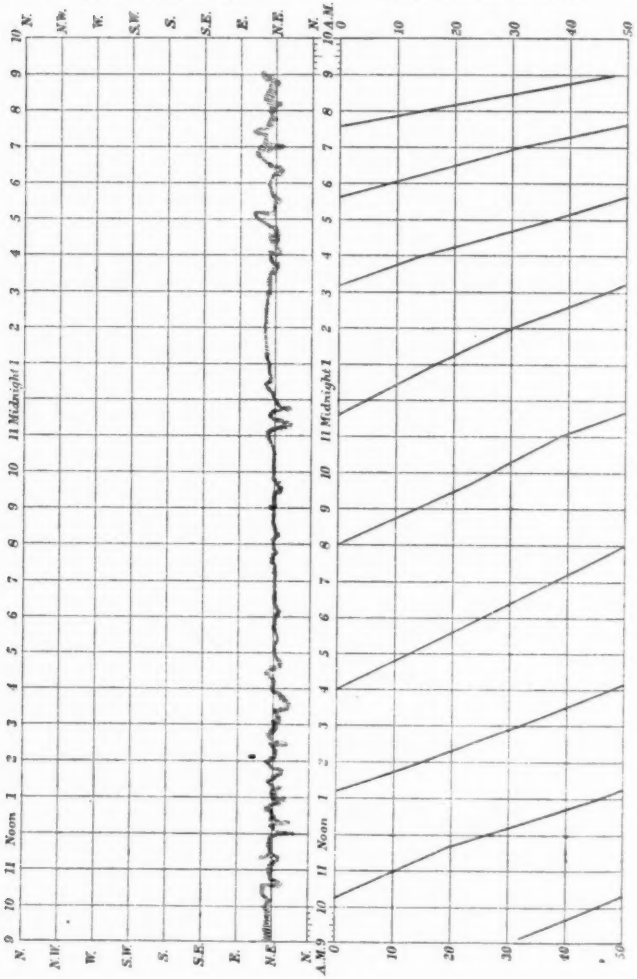


PLATE III.

ROYAL ALFRED OBSERVATORY, MAURITIUS.

ANEMOGRAPH CURVE No. 120.

From Friday, April 29d 9h 4m to Saturday, April 30d 7h 30m, 1892.

The space travelled over is obtained by multiplying by (Dr. Robinson's original Factor) the distance actually run by the cups.

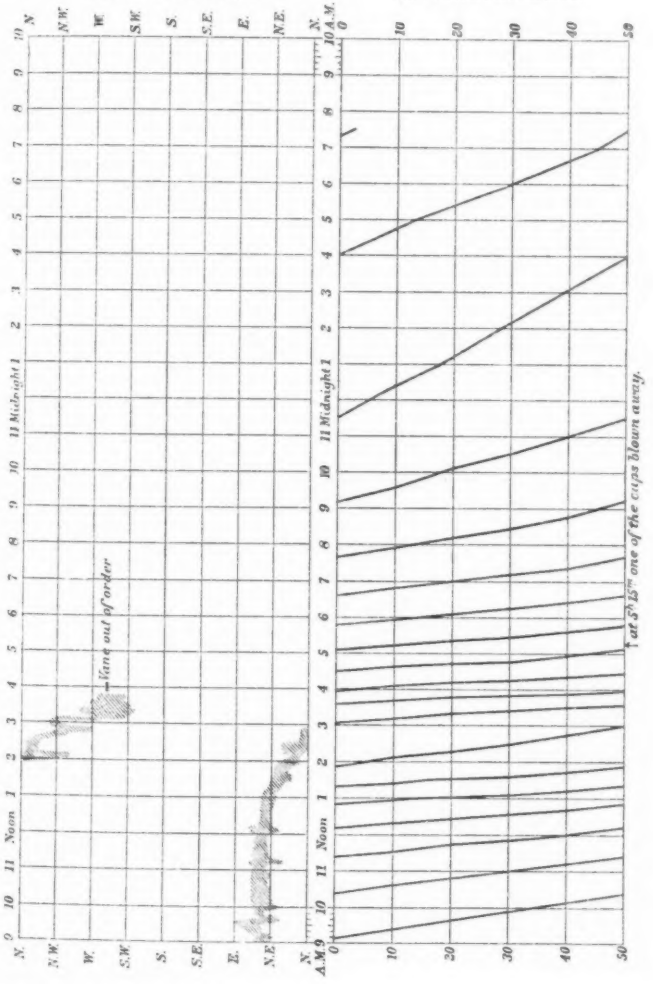


PLATE IV.

ROYAL ALFRED OBSERVATORY, MAURITIUS.

THERMOGRAM.

Started Thursday, 28th April, $7^h\ 42^m$ M. M. T.
Stopped Saturday, 30th April, $7^h\ 28^m$ " " "

* Hurricane; lamp not burning.

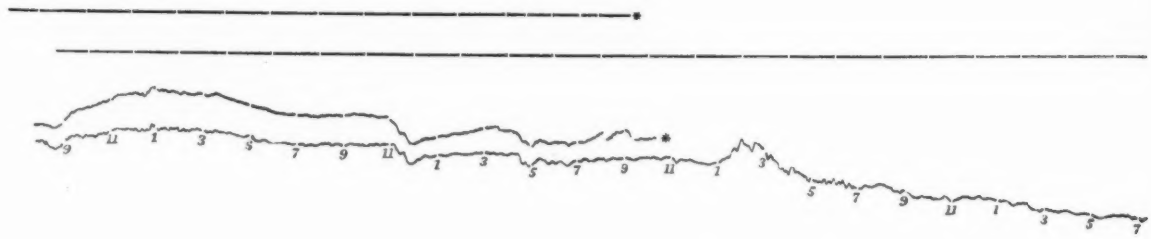
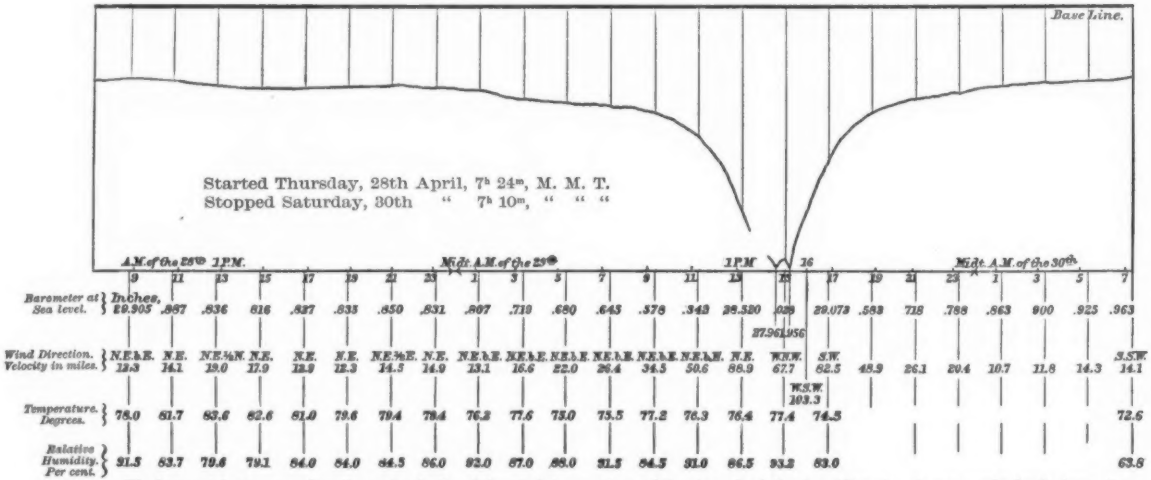


PLATE V.

ROYAL ALFRED OBSERVATORY, MAURITIUS.

Barogram before, during, and after the Hurricane of April 29, 1892.



The barometric pressure, direction and velocity of the wind, temperature of the air, and relative humidity given here are only for the hours 9 a. m., 11 a. m., 1 p. m., (13 hours,) 3 p. m., (15 hours), &c.

The velocities are the average velocities for a whole hour, viz., from 8½ to 9½ a. m., 10½ to 12½ a. m., &c.

The hourly values of the barometric pressure &c., are given on a separate sheet, (Plate VII.)

From 1.20 to 2.08 p. m., the flame of the barograph lamp was too low for recording the pressure. Thinking this would be the case, advantage was taken of a decrease of wind to send one of the assistants to the barograph room (in an outside building) to raise the flame, and the lowest pressure was recorded.

PLATE VI.

ROYAL ALFRED OBSERVATORY, MAURITIUS.

Barogram as supplemented by personal observations.

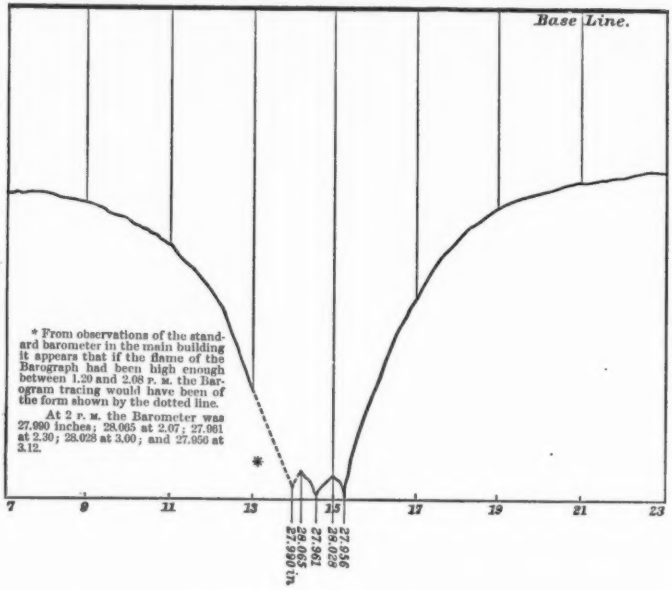

Base Line.
* From observations of the standard barometer in the main building it appears that if the flame of the Barograph had been high enough between 1.29 and 2.08 P. M. the Barogram tracing would have been of the form shown by the dotted line.
At 2 P. M. the Barometer was 27.990 inches; 28.065 at 2.07; 27.961 at 2.30; 28.025 at 3.00; and 27.956 at 3.12.
*
7
9
11
13
15
17
19
21
23
27.990 in.
28.065
27.961
28.029
27.956

PLATE VII.

ROYAL ALFRED OBSERVATORY, MAURITIUS.

Hourly values of the Barometric Pressure, Temperature of the Air, Relative Humidity, Direction and Velocity of the Wind, and Rainfall from midnight of the 28th to midnight of the 29th of April, 1892. *Cistern of Barometer* 180.86 *feet above sea-level.*

	28th	29th											29th												29th
Hours.	Mid-night	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p m.	Mid-night
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
Pressure 20 in.+	9.809	9.807	9.741	9.719	9.701	9.680	9.663	9.645	9.630	9.578	9.477	9.342	9.062	8.520	7.990	8.028	8.536	9.073	9.396	9.583	9.616	9.718	9.748	9.788	9.839
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°							
Temperature ...	75.3	76.2	77.0	77.6	77.3	75.0	75.6	75.5	77.0	77.2	76.2	76.3	76.3	76.4	.....	77.4	.....	74.5	*a*						
Rel. Humidity..	89.0	92.0	89.0	87.0	87.0	88.0	91.0	91.5	86.0	84.5	91.0	91.0	87.5	86.5	.....	93.2	.....	83.0	*a*						
Wind. Direction...	N.E.	N.E. b. E.	E. N.E. ½ N.	N.E. b. E.	N.E.	N.E. b. E.	N.E. b. E.	N.E. b. E.	N.E ½ E.	N.E. b. E.	E. N.E. ½ N.	N.E b. E.	N.E. ½ E.	N.E.	N.	W. N.W	W. S.W.	S.W.	*b*						
Wind. Velocity....	12.4	13.1	14.9	16.6	20.8	22.0	22.4	26.4	34.7	34.5	40.1	50.6	71.6	88.9	65.1	67.7	103.3	82.5	*c*60.5	48.9	37.4	26.1	21.6	20.4	12.6
Rainfall, inches.	.190	.000	.000	.000	.010	.070	.087	.030	.135	.020	.140	.440	.652	.370	.220	.010	.390	.220	*d*						

a Lamp of Thermograph blown out.
b Vane of Anemometer damaged.
c One of the cups of the Anemometer blown away at 5.15 p. m.
d Pluviograph ceased to act.
e The velocities of the wind are the average velocities in miles for an hour.
f The greatest average velocities for one hour were 88 9 miles from half past noon to half past 1 p. m., and 103.3 miles from 3.30 to 4.30 p. m.
g From 1.27 to 1.32 p. m. the velocity was at the rate of 104 miles an hour. It then decreased (as afterwards shown by the Anemogram) to the rate of 34 miles an hour from 2.30 to 2.59 p. m., and then increased to the rate of 121.2 miles an hour from 3.46 to 3.51 p. m., after which it decreased. These rates of velocity for short intervals were found by carefully watching and recording the movements of the velocity index of the Anemometer.

The Climate of Galveston, Texas. — Mr. I. M. Cline, local forecast official of the United States Weather Bureau at Galveston, Tex., has recently published in the Galveston *Daily News*, an article on the climate of that city. In the course of the paper the writer says: —

"The meteorological writer in the 'Encyclopedia Britannica,' in speaking of Texas, quotes from Robert Russell's 'Climate of America' the statement that the temperature has been known to fall in southern Texas, with a norther, from 81° to 18° in forty-one hours. This statement is far from being verified from twenty years' records at Galveston. The greatest difference during the twenty years in the highest and lowest of an entire month is 58°, which is considerably less than the range quoted here, 63° in less than two days, would have been. By reference to the table, the reader can see the number of years the minimum has been below 32°; and there are four years in which the lowest temperature has not been below 32°; it has not been below 24° in thirteen years; and it has only been below 20° two years. Another striking feature in the climate of Galveston is that the thermometer has never reached 100°, the highest on record being 98°. July is the only month in which the maximum temperature reaches 90° in every year; it has reached that point in eighteen years during August, in fourteen years during June, in eight years during September, and in three years during May.

"Another feature which shows the unusual equability in the climate of Galveston is the small average diurnal range in temperature, and the small number of days on which excessive daily changes and departures from the normal occur.

"The average per cent of moisture in the atmosphere varies from 74 during summer and autumn to 83 in February, and the mean monthly ranges generally between 70 and 80 per cent.

"In precipitation, Galveston has a good average,—52.48 inches per annum; the greatest occurs in September and the least in February.

"Continued cloudy or foggy periods are rare, and from close approximation it is believed that the sun shines, to a greater or less extent, on eighty-five days out of every hundred the year round.

"The prevailing wind is south to southeast, with an average velocity of eight to twelve miles per hour; and it might be added that it is to the wind that the climate of Galveston owes its salubrity and equability, as, coming fresh from the sea, it is free from impurities carried in the atmosphere by land breezes. From a study of the highest velocities during each month in the year, it will be observed that Galveston is not subject to very high winds; that they are greatest in winter and least in summer; also that the highest velocity is generally from northerly directions."

Meteorological Work at the Colorado Agricultural Experiment Station. — The Fourth Annual Report of the Colorado Agricultural Experiment Station contains an interesting account of the meteorological work being done at that institution under the direction of Prof. L. G. Carpenter. Observations are taken twice daily by eye-readings of the principal instruments, with records from several self-recording instruments. The daily

amount of sunshine is automatically recorded, and afterwards measured. Special studies have been made on various points, including the relation of the dew-point and frost, the change in temperature of the air from the ground upwards, etc. Special attention has been given to records of precipitation, — a subject of great importance in connection with the irrigation question in Colorado. The winter months have the least precipitation, the early summer months the greatest. Prof. Carpenter notes that "physical conditions undoubtedly govern the rainfall to some extent. It is a prevailing opinion that certain strips are more exposed to rain and hail than others, and certain other locations are proverbially dry. To how great an extent this will be noticed in careful observation, is yet to be determined. . . . Common belief points out locations where hail strikes almost every season, and other neighboring localities where no serious damage has been done since the country was settled." A precipitation table for 1891 gives data for a comparison of the difference in amount of rainfall according to elevation and location. A steady decrease in the amount of rainfall is noted from the highest station to Fort Collins, which is on the plains, and an increase is noted from Fort Collins eastward. "The mountain stations," Prof. Carpenter says, "derive their moisture almost entirely from the western currents, and this falls as we pass from their summit. Eastward, the effect of the supply from the Gulf of Mexico becomes important." Observations on the amount of evaporation have also been made. Tables are given of the amount of sunshine recorded in each month, of soil temperatures, of the readings of terrestrial radiation thermometers, etc. The temperature during the winter months is frequently higher at Manhattan, 3,500 feet above Fort Collins, than at the latter place. In January the temperature at 7 A. M., at Fort Collins, averages five degrees lower than at Manhattan.

Rain-Clouds on Pike's Peak. — Mr. G. W. Tinsley, of Columbus, Ind., has recently made some interesting observations on the formation of rain-clouds over Pike's Peak. He describes the formation, in the early morning of Aug. 10, of a small white cloud above the peak, which, after forming and dissolving for an hour or more, finally attained a considerable size, and then moved off in a southeasterly direction along the mountain chain. Rain fell on the peak, but when the cloud reached the Cheyenne Mountains, fifteen miles distant to the southeast, all appearance of rainfall had gone, and the cloud rapidly dispersed. Similar occurrences were observed several times-though occasionally the clouds which formed over the peak brought rain to the lower ground. Mr. Tinsley notes: "Clouds generally form from three to five thousand feet above the peak. When a storm is raging on the peak, and but little larger in diameter than the top of it, there is nothing to indicate an uprush of air to supply these tons of water that are falling. In fact, if you are close to it, you will find a strong outward flow of air, caused by the downpour, the same as you will find at the front and at the bottom of any considerable waterfall."

The diurnal change in wind direction is noted as follows: As the sun warms the air in the valley, it gives to it a westward movement, which carries it against the mountains lying in a S. E.-N. W. direction. The result is a

deflection of the warmed air to a northwesterly direction. When the temperature begins to fall in the afternoon, the wind shifts to northwest, and blows down the mountain sides into the valley.

New England Meteorological Society. — The Ninth Annual Meeting of the New England Meteorological Society was held in the Massachusetts Institute of Technology, Boston, on Oct. 26, 1892. The following were elected officers for the ensuing year: *President*, Prof. W. H. Niles; *Secretary*, Prof. W. M. Davis; *Treasurer*, R. DeC. Ward; *Council*, Prof. Winslow Upton, A. L. Rotch, C. H. Webster. Mr. J. Warren Smith, Director of the New England Weather Service, read an interesting report upon the work of that service, and Mr. S. P. Fergusson, of the Blue Hill Observatory, presented a paper upon "Anemometer Comparisons." These papers will appear in the January number of this JOURNAL. A discussion on the Prediction of Thunderstorms was opened by Mr. R. DeC. Ward.

A New Physical Atlas. — A prospectus has recently been issued of a new physical atlas, to be compiled by J. G. Bartholomew, F. R. S. E., F. R. G. S., and H. R. Mill, D. Sc., F. R. S. E. The atlas will be based on the work of Berghaus, and will contain a hundred maps. Prof. James Geikie, Dr. John Murray, Sir Archibald Geikie, Dr. Buchan, and Prof. Bayley Balfour have already been secured as contributors, and other specialists will also be asked to assist in the work. The atlas is to be issued in sections.

CORRESPONDENCE.

SEA WATER TEMPERATURES AT ATLANTIC CITY, N. J.

Editor of the American Meteorological Journal:

I enclose herewith a summary of the observations of the sea water temperatures referred to in the October number of the JOURNAL (p. 291), taken at Atlantic City, N. J., from Aug. 4 to 31, 1892: —

TEMPERATURE OF AIR.

Average at 9.45 A. M., 74.9; at 12.45 P. M., 75.8; mean, 75.4.
Highest at 9.45 A. M., 81.5 on the 20th; wind N. W.
Lowest at 9.45 A. M., 66.6 on the 27th; wind N.
Highest at 12.45 P. M., 84.0 on the 15th; wind N. W.
Lowest at 12.45 P. M., 67.0 on the 27th; wind N. E.

TEMPERATURE OF WATER.

9.45 A. M.

At surface, 75.3; at bottom, 75.2; average, 75.2.
Highest at surface, 78.8 on the 10th; wind S. W.
Lowest at surface, 72.5 on the 13th; wind N.
Highest at bottom, 78.6 on the 10th; wind S. W.
Lowest at bottom, 72.5 on the 13th; wind N.

12.45 P. M.

At surface, 76.8; at bottom, 76.6; average, 76.7.
Highest at surface, 81.5 on the 11th; wind S. W.
Lowest at surface, 72.0 on the 12th; wind N. W.
Highest at bottom, 80.6 on the 10th; wind S. W.
Lowest at bottom, 72.0 on the 12th; wind N. W.
Average depth of water, 5.9 feet.

PREVAILING DIRECTION OF WIND.

At 9.45 A. M., S. W., 21 %; at 12.45 P. M., S., 29 %.
For the month, S., 20 %; S. W., 20 %.
Easterly winds (N. E. to S.), 54 %.
Westerly winds (N. to S. W.), 46 %.

The work of taking these observations, and publishing the result by bulletin and otherwise, was taken up, with the consent and assistance of the Chief of the United States Weather Bureau, in the belief that (1) the information would be of interest and benefit to the many thousand persons who visit this

"city by the sea," and "dip in old ocean" during the summer; and (2) that the prevailing direction and changes in the direction of the wind very greatly influence, and are the principal causes of, the fluctuations in the water's temperature; and that from a record of such observations, covering the bathing seasons of a few years, facts might be established that would enable a competent weather forecaster to make very nearly accurate predictions of the bathing conditions, twenty-four to forty-eight hours in advance.

The fact that the daily newspapers published the data regularly, and many of the principal hotels and bath-houses called for it daily, and kept it posted in bulletin form for the information of their patrons; and also that each of the two commercial and two railroad telegraph companies called for and distributed the data free to principal points on their lines throughout Pennsylvania and New Jersey, seems to be sufficient evidence that the information was sought after by the public. Whether the second proposition, or theory, will prove correct, cannot, of course, be determined as yet. But, as may be seen by reference to the record, there was at least one instance, during the period covered, which indicates that the theory may be verified, viz.: Aug. 12, when, after forty-eight hours of southwest wind, during which time the temperature of both the air and water gradually increased, a change in the direction of the wind to west and northwest was quickly followed by a fall of 9.5 degrees in the temperature of the water, with practically no change in the temperature of the air.

The observations were taken from Young and McShea's, Ocean Pier, foot of Tennessee Avenue, which, extending as it does, about fourteen hundred feet into the ocean, affords excellent facilities for taking the readings at any depth of water required, from 0 to 15 feet. The point on the pier from which the readings were taken, varied from day to day, with the tides, and averaged about four hundred feet from the water's edge, the aim being to get the temperatures of the water, at surface and bottom, as nearly as possible to the outer line of the bathing grounds for the day.

W. T. BLYTHE,
Observer, Weather Bureau.

ATLANTIC CITY, N. J., Sept. 7, 1892.

FAYE'S THEORY OF CYCLONES. (*Translated.*)

Editor American Meteorological Journal:

I have read with interest the article which Mr. W. C. Moore has devoted to the refutation of my theory of cyclones, but I have not been convinced by it. The fundamental idea of this theory is that cyclones, trombes, and tornadoes are descending whirls. Mr. Moore has spoken only of cyclones. I would like to have the learned author examine also the other phenomena which are evidently of the same kind. Then I would undertake to reply to him, if you think that I can do so in your esteemed JOURNAL. I will confine myself at present to stating that tornadoes are frequently seen descending from the clouds, and that there can be no illusion with regard to this, while as regards cirrus clouds, observation is a matter of extreme difficulty,

and I do not hesitate to say that those who have thought they saw a diverging movement in these clouds reasoned under the influence of a preconceived idea, — that of the ascending movement of the air in cyclones and tornadoes. While speaking of this subject I think I ought to refute the assertion of Mr. Moore, who reproaches me with accusing meteorologists of a lack of sincerity in trying to make their facts accord with a preconceived theory. The history of science is full of these attempts, without our being able on that account to accuse their authors of a lack of sincerity. I believed, and I still believe, that the theory of the ascensional movement of cyclones and tornadoes has induced its partisans to see the facts in an entirely false light; but I say again, I am far from accusing them of falsifying the facts on purpose.

Moreover we have an admission that the simple convectional theory does not sufficiently account for the phenomena, since Mr. Moore distinguishes between real convection and apparent convection; and we know besides, through the writings of Dr. Hann and of Prof. W. M. Davis, that the cyclones of the temperate regions cannot be explained by the simple convectional theory. Further, Mr. Dallas has shown in his article on the Cyclones of the Indian Region (Am. Met. Jour., July, 1892) that "with regard to the controlling influence on the progressive motion of cyclones, all available evidence seems to show that this is centred in the movements of the upper atmosphere." Thus what Hann and Davis say regardiug the cyclones of temperate regions holds also for those of the torrid zone. Both have their origin aloft and not on the surface of the earth. They therefore descend.

H. FAYE.

PARIS, Sept. 14, 1892.

INSTINCT AS A WEATHER PROPHET.

Editor American Meteorological Journal:

That many of the lower animals are possessed of remarkable instincts or peculiar faculties which to a greater or less degree serve to foretell weather changes seems to be substantiated by the result of close observation. The majority of weather proverbs relating to living creatures are, to say the least, unreasonable and unreliable; yet the fact that certain animals do possess remarkable faculties which man does not possess would reason for the possibility of extraordinary powers even in this respect. Some birds and insects, for instance, possess the migratory instinct. It is certainly not reason that directs them to fly southward or northward for change of climate rather than eastward or westward. They seem possessed of a peculiar, natural, intuitive power which directs them. The dog is possessed of unusual and extraordinary development of the sense of smell. The cat may be blindfolded and taken a long distance to a strange place and yet, through the evident power of some directing influence, it usually experiences little difficulty in finding its way home. Even in the human family are found prodigies possessed of unusual powers, — powers not acquired, but instinctive and unaccompanied by the exercise of reason. These prodigies perform

remarkable feats, yet are unable to explain their own methods, showing that their supernatural powers are more of instinct than of reason. The weather prognosticator, also, by experience, acquires a certain intuitive knowledge of weather conditions which though inexplicable is yet of great service and none the less real. Hence it happens that dissimilar forecasts are frequently made from apparently similar atmospheric conditions.

All of these illustrations go to show that living beings may be, and frequently are, possessed of peculiar powers which are unaccompanied by the exercise of reason and which, though possessed by some more fully than by others, may be the common possession of all, though all do not recognize them.

These powers, so far as they relate to the weather, may vary largely with the physical needs and hence the physical peculiarities of different animals. The snail, for example, never drinks, but like a sponge absorbs or imbibes moisture during rain and exudes it during fair weather. The spiders, ants, worms, toads, and other insects and smaller vertebrates are also much affected by wet weather, and hence might be expected to possess instincts enabling them to take due precaution for their protection, comfort, and convenience. As has been said, there is evidence that they do possess such instinct. Of the snail, which is almost wholly dependent upon the rain for its moisture, certain species are noticed to present a yellowish appearance before, and a bluish appearance after, a rain, while others indicate approaching rain by the appearance of protuberances or indentations, which, when the rain comes, open their pores and imbibe the moisture. It has also been noticed that snails are seldom seen abroad except shortly before a rain, when they expose themselves upon trees, leaves, grass, and other objects, to receive the approaching shower. Spiders have been observed to make changes in their web in order, evidently, to protect it from damage by the rain.

There are numerous other animals for whom this instinct is claimed. The examples given indicate the possibility of the existence of such remarkable faculties, at least among certain classes, and this possibility — if not probability — suggests the importance of further research along this line.

W. J. WAMBAUGH.

AUGUSTA, GA., Sept. 20. 1892.

LOCAL WEATHER SIGNS.

Editor American Meteorological Journal:

Prof. Harrington's observation in the pamphlet on "Meteorological Work for Agricultural Institutions" to the effect, "It is important that all means of local forecast, independent of the weather map, should be carefully studied, and when any one is found useful it should be published in such a way as to be put at the service of those interested in it," is a timely one, and it is apparent that the only thing essential for farmers and others to do is to become familiar with such local phenomena; and if deductions are correct, there will be less uncertainty in forecasting rain.

In every community there exist local "signs" for rain, varying from the chirping of the "rain-crow" to the basso profundo medley of the frog, whose croakings emanate from some distant pond.

Years of experience impress me with the heretofore recognized fact that certain kinds of clouds and direction of same are potent factors in forecasting rain.

After some days of good weather, if cirrus, cirro-cumulus or cirro-stratus clouds appear, moving from a southwesterly or westerly direction, the chances are nine to ten in favor of rain during the night, or on the following day. These clouds usually precede a norther, speaking locally.

If those concerned would familiarize themselves with the various local phenomena (in this case kinds of clouds) the interrogatory, Will it rain to-morrow? will be found not so perplexing.

A. J. MITCHELL.

WEATHER BUREAU, JUPITER, FLA.

BIBLIOGRAPHICAL NOTES.

SAMUEL LOCKWOOD. *The Hygiene of the Atmosphere.* North American Review. Vol. CLV., No. 4. October, 1892; pp. 446–455.

It is only within the last few years that the dust of the atmosphere has received much attention from meteorologists, but now through the recent painstaking investigations of Mr. Aitken, we have learned how important is this dust in the formation of fog and rain. The modern science of bacteriology, also, has made us familiar with the fact that the atmosphere contains myriads of microbes, working for good or evil. In his paper Prof. Lockwood deals with the question of these bacteria in the atmosphere, which, he says, are really plants, perpetuating their species either by self-division or by spores. They are possessed of marvellous vitality, retaining their vigor even though frozen in ice, and the spores of some of them resisting the heat of water nearly to the boiling point. There are diurnal fluctuations in the number of these bacteria in the atmosphere. They are very numerous at about eight o'clock in the morning, decreasing in number until noon, increasing again until a maximum is reached at about eight o'clock in the evening. From midnight till three o'clock they diminish in numbers, and then increase again till the morning maximum at eight o'clock.

In concluding his paper Prof. Lockwood gives the result of some investigations he made during the past summer with reference to the cause of hay fever, which he believes to be due to the dust in the atmosphere. We quote the author: —

"A distressing malady is æstivis, or hay fever. Behind the disease is a neurosis, or supersensitiveness of the nerve centres. The air passages have their mucous walls in a disordered condition, and in a state of tenderness not unlike that of the outer flesh when scalded or denuded of the skin. Hence, generally, air dust of any kind is a painful irritant to the mucous surface. And probably this is especially true of the organic or vegetable matter in the air. As president of the United States Hay-Fever Association, it seemed my duty to throw some light on the question of the difference of the air in places where æstivis prevailed, and the regions sought as sanitaria being largely exempt from the malady. Possibly in these mountain retreats, owing to the resins of the balsam forests, peroxide of nitrogen, mistaken for ozone, is present. The air, too, is dryer and its average much cooler, all of which makes the summer climate more tonic. Yet it seemed to me that the chief factor was to be sought in the character of the air dust itself. In a word, the instrumental work was less with the barometer and thermometer than with the microscope. Accordingly, in August and September, at my retreat in the White Mountains, at an elevation of about one

thousand five hundred feet, I set traps to catch the contents of the air, instructing my son, by correspondence, to do the same at the same time at my home in New Jersey, at an elevation of nearly three hundred feet above the sea. His daily catch was put away in an air-tight box to be studied on my return. My particular quest was pollen, and only on two traps in fifty did I find any. One yielded five grains of aster pollen, and another three grains of spiræa. This paucity of pollen was a genuine surprise. The study of the home slides afforded an astonishing contrast. A single trap gave me over two hundred pollen grains of ragweed, or Roman wormwood, probably the very worst irritant of æstivis. Then there was hardly a slide without pollen of some kind. Time will not allow for technical descriptions, but there were pollens also of other plants, though the ragweed dominated largely over all. There was mineral dust, too, in great quantity, woody matter, and considerable *débris* of an artificial sort, such as fibres of woolen and cotton goods, peculiar to populous places. Scales of insects, great quantities of very fine vegetable exuviæ that I have likened to epithelial scales, were present in profusion. But, to my surprise, the traps showed a considerable amount of fungus spores, rather pretty, but decidedly unlovable objects when once inside the air passages. In my judgment, of the ingredients which make up the air dust, pollen, especially that of the ragweed, is the worst for the sufferer from hay fever."

JOHN C. ADAMS. *A Chapter in Meteorological Discovery.* Popular Science, Monthly. Vol. XLI., No. 6, October, 1892, pp. 787–797.

Mr. Adams has given us in his article a short and necessarily incomplete summary of the main points in the meteorological work of Franklin, Redfield, Espy, Loomis, and Henry, including mention of Hare, Blodgett, Mitchell, and Coffin. The statement that Redfield maintained that the wind blows around a centre of low pressure in a vortex needs some qualification, for the discussion between himself and Espy was due to the fact that he for some years wrote as if he held that the winds blow in circles around areas of low pressure, Espy maintaining that they blow radially inward to the centre. In 1839, however, Redfield wrote as follows: "In the most violent of these storms it is at least probable, if not certain, that the course of the surface winds is spirally inward, approximating gradually towards the centre of the storm."

It is a matter of regret that no mention is made in this article of Ferrel, the greatest of American meteorologists. Certainly no "chapter of meteorological discovery" can be complete without some account of his work, and yet his name does not once appear here. We are glad to note that our monthly magazines are giving some space to meteorological articles, and hope that at least the names of Redfield, Espy, Loomis, and Ferrel may soon become familiar to the American public.

PUBLICATIONS RECEIVED.

"Astronomy and Astro-Physics," Northfield, Minn., October, 1892.

"Pilot Chart of the North Atlantic Ocean." Published monthly by the Hydrographic Office, Bureau of Navigation, Navy Department, Washington, D. C., Richardson Clover, Lieutenant Commander, U. S. N., Hydrographer. September and October, 1892. The September issue has a chart showing the drift of the bow and stern of the ship "Fred. B. Taylor," which was cut in two in collision with the steamship "Trave" on June 22, in latitude 40° 19′ N., longitude 68° 33′ W. From that point the forward and after parts separated and drifted in entirely different directions, this being perhaps due to the different areas they respectively present to the wind and ocean currents. The bow took a southeasterly course, attributable largely to the cold southerly current between the coast of the United States and the Gulf Stream. The stern took a northerly course, being evidently more influenced by the wind than the bow. The October issue of the "Pilot Chart" has a small chart of the hurricane of Aug. 23–25, 1892. The data with regard to this hurricane seem to indicate that it followed a very unusual track in the tropics, moving apparently in a southwesterly direction, toward St. Thomas, before taking the usual northwesterly track.

"Report of the Alabama Weather Service, in Co-operation with the United States Department of Agriculture, Weather Bureau," Auburn, P. H. Mell, observer Weather Bureau, director. August, 1892.

"Monthly Review, Bulletin and Crop Report of the Arkansas Weather Service, issued in Co-operation with the Arkansas Bureau of Mines, Manufactures, and Agriculture," Little Rock, M. F. Locke, director; F. H. Clarke, observer, Weather Bureau, assistant director. August and September, 1892.

"Monthly Review of the Iowa Weather and Crop Service, in Co-operation with the United States Department of Agriculture, Weather Bureau," Des Moines, J. R. Sage, director; Geo. M. Chappel, M. D., assistant director. August, 1892.

"Monthly Bulletin of the Iowa State Board of Health." Published at the office of the Board at Des Moines, Iowa; J. F. Kennedy, A. M., M. D., editor. Vol. VI., No. 3, August, 1892.

"Monthly Report of the Maryland State Weather Service, in Co-operation with the United States Department of Agriculture Weather Bureau," Baltimore, Prof. Wm. B. Clark, director. August, 1892.

"Michigan Crop Report of the Michigan Weather Service," Lansing. Published by Robert R. Blacker, Secretary of State. August, 1892.

"North Carolina Agricultural Experiment Station, Bulletins Nos. 86c, 86d, 87a, State Weather Service Division, Nos. 32, 33, 34," Raleigh, H. B. Battle, Ph. D., director. Sixteen pages.

"Bulletin of the North Dakota Weather Service, in Co-operation with the United States Department of Agriculture, Weather Bureau," Bismarck, W. H. Fallon, observer Weather Bureau, director. August, 1892.

"Monthly Bulletin of the Texas Weather Service, issued in Co-operation with the Galveston Cotton Exchange," Galveston, July, 1892.